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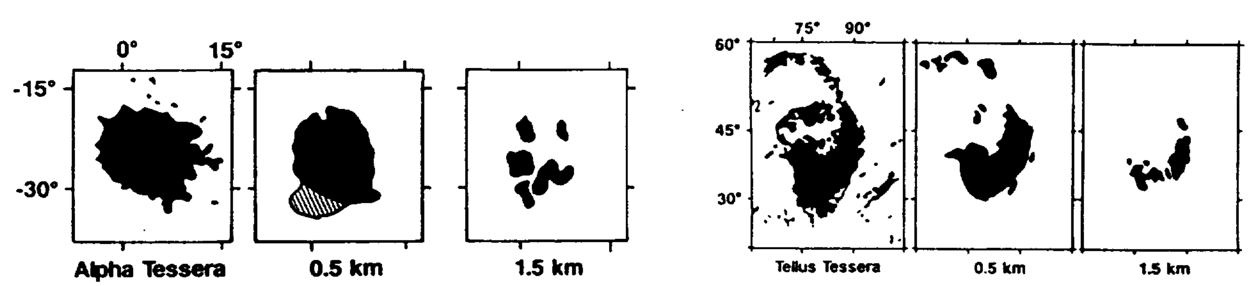
TESSERA TERRAIN ON VENUS: IMPLICATIONS OF TESSERA FLOODING MODELS AND BOUNDARY CHARACTERISTICS FOR GLOBAL DISTRIBUTION AND MODE OF FORMATION; James W. Head[1] and Mikhail Ivanov[1,2]. [1]Department of Geological Sciences, Brown University, Providence RI 02912; [2]V. I. Vernadsky Institute of the Russian Academy of Sciences, Moscow, Russia.

Introduction: Mapping of tessera terrain using Magellan global high-resolution data has shown that it comprises about 10% of the surface area of Venus, is not randomly distributed, is extremely highly deformed relative to intervening plains, lies at a wide range of elevations, is embayed by and largely predates adjacent volcanic plains, is generally negatively correlated with broad lowlands and volcanic rises, may underlie a considerable percentage of the superposed volcanic plains, and has linear/tectonic margins for about 27% of its boundaries (1,2). In this paper we investigate further the distribution and origin of tessera through analysis of the changing nature of tessera occurrences during sequential flooding, and assessment of the nature and distribution of Type II (linear/tectonic) tessera boundaries (2,3).

Models of Sequential Flooding of Tessera Terrain: Global mapping of tessera shows that the number of small tessera patches far exceeds those of medium and large size, although small tessera patches make up only a small part of the total tessera population by area. These observations, together with the volcanically embayed nature of about 73% of the boundaries of tesserae, the wide areal distribution of small patches (1), and the common presence of small patches adjacent to larger ones, has led to the hypothesis that tessera terrain may underlie larger portions of the surface than the ~10% presently exposed. In order to test this hypothesis and to assess quantitatively the amount of volcanic cover that may overlie such a tessera basement, we developed a series of volcanic flooding models to study volumes, thicknesses, and outcrop patterns of tesserae flooded by volcanic deposits. We report here on the first stage of this analysis, in which we take known major areas of presently exposed tessera (Alpha, Tellus, Laima, Fortuna, Thetis, and Ovda), flood them evenly to specific contours above MPR, and track the relationship between lava thickness and changing outcrop patterns (Fig. 1). Alpha Regio Tessera: Flooding of the Alpha region to 0.5 km above MPR removes all outliers of tessera and reduces the area of the main occurrence by less than about 20% but does not modify its coherence. Flooding an additional 1 km to 1.5 km reduces the outcrop pattern by more than 50% and results in five outliers, each with a different shape and orientation and less than about 500 km in mean width, replacing the coherent Alpha tessera. Flooding to 2.5 km removes all trace of Alpha tessera. Tellus Regio Tessera: Flooding to 0.5 km results in loss of virtually all outliers, in the reduction of the northern arc and outlier to several small patches, and reduction of the main occurence area by about 10%, although it retains its coherence. Flooding to 1.5 km reduces the outcrop pattern by more than 50% and results in six outliers, two large ones and four small ones, replacing the coherent main Tellus tessera. Flooding to 2.5 km removes all trace of Tellus tessera (Fig. 1). Laima Tessera: Flooding to 0.5 km removes outliers and begins to embay the southern and eastern margin of Laima. Because Laima is on a regional slope leading northwestward to Ishtar Terra, flooding to 1.5 km causes systematic embayment for 500-1000 km in a NW direction, forming about ten outliers of tessera SE of the main body, now reduced to less than 50% of its original extent. Flooding to 2.5 km reduces the total tessera outcrop to a single 250 x 500 km patch. Fortuna Tessera: Flooding to 0.5 km causes large-scale embayment and breakup of northern Fortuna. Because of the E-W trending large-scale topographic fabric, flooding to 1.5 km causes systematic breakup of the main tessera body into a highly embayed southern block and a northern outlier. Total outcrop is now reduced to less than ~70% of its original extent. Flooding to 2.5 km reduces the total tessera outcrop to a series of about six patches extending in an E-W direction. Thetis Tessera: Thetis consists of a northern highly embayed and segmented portion, and a southern highly embayed but more coherent portion. Flooding to 0.5 km causes virtually no modification, while flooding to 1.5 km removes much of the northern segments of tessera. Because of the steep sides of the southern segment, flooding to 3.5 is required to seriously alter the outcrop pattern, and even then the outcrop pattern is coherent and arc-like. Ovda Tessera: Flooding to 0.5 km removes a few outliers but has no major effect on the main tessera distribution. Flooding to 1.5 km removes a large portion along the western end (~15-20% of the total), but has little influence elsewhere. Increasing levels of flooding remove portions of the western end and isolate the high region to the east until at 3.5 km thickness, there is one major (~2000 x 3000 km) outcropping that still is coherent. Summary: Flooding of presently exposed tessera terrains such as Alpha and Tellus to 1.5 km above MPR produces outcrop patterns similar to the widely distributed clusters of small tessera patches common on Venus (1), and flooding to 2.5 km totally obliterates all tessera patches. Flooding of Fortuna to 2.5 km would yield a patchy distribution of tessera similar to the present outcrop patterns of Ananke or Meshkenet tesserae. Flooding of Ovda and Thetis to 3.5 km would produce tessera outcrops which had an areal extent only 1-2 times that of present-day Alpha tessera. This simple exercise supports the idea that the widespread areas presently characterized by tessera patches and clusters (1) may have tessera terrain underlying the plains at depths of several hundred meters to 1-3 km. It also demonstrates that all traces of tessera terrain for significant regional occurrences (e.g., Alpha, Tellus) can be removed from sight by as little as 2-4 km thickness of volcanic plains.

Characteristics of Tectonic Boundaries of Tessera Terrain: Abundance: Classification of tessera boundaries has shown that 27% are Type II, more linear at the tens to hundred kilometer scale and usually associated with large-scale tectonic features bounding tessera massifs. Association with tessera topography and structure: For large tesserae the linear boundary often coincides with the high elevated edges of the tessera, and ridges and troughs inside the tessera are in general oriented subparallel to this boundary. Continuity: Some Type II boundaries occur locally (interrupting regional Type I embayed boundaries), but many form regionally continuous parts of boundaries that extend for hundreds to thousands of km (e.g., along the northern edge of Itzpapalotl and Fortuna). Boundary Shapes: One of the modes of occurrence for tesserae boundaries and tesserae patches is in arc-like arrangements which may extend for thousands of km: examples are the northern boundaries of Itzpapalotl-Fortuna Tessera and Itzpapalotl Tessera; Kutue-Ananke tessera chain at the edge of Akkruva Colles Region; Dekla tessera; tesserae at the northern margin of Beta Regio and at Phoebe Regio. In most cases, Type II linear/tectonic boundaries dominate at these arcuate patch/boundary occurrences. Symmetry: Type II boundaries are generally asymmetrical in large tessera occurrences, existing on one side but commonly not on the other (e.g., Fortuna, Ovda). In some smaller linear cases (e.g., Tethus) the boundaries occur on both sides. Age: In some cases, border deformation has extended over a period of time and has involved adjacent plains (4) while in others the boundary has been embayed by plains which are not clearly deformed; in still others, the slopes are sufficiently steep as to suggest geologically recent activity (5). Associations with convection patterns: Comparison of these boundaries to interpreted present patterns of mantle convection (6) show very little correlation. Arcuate Type II boundaries are commonly not closely associated with or oriented appropriately to suggest a relationship to regions interpreted to represent present patterns of upwelling and downwelling. Summary and interpretation: The linearity of Type II boundaries and the association with large scarps or tectonic features suggest that these boundaries formed at tectonically active edges of tesserae. The common asymmetry of occurrence of many of these boundaries would suggest that processes responsible for their formation are dynamic and not just passive gravitational relaxation. The regional arcuate nature of many Type II boundaries suggests that they may mark the location of large-scale flexure and overthrusting and/or underthrusting. Lack of correlation with present mantle convection patterns suggests that many Type II tesserae boundaries may be the product of previous convective activity or other processes, such as relicts of large-scale overturn processes (7).

Summary: Flooding models suggest that tessera may be much more widespread beneath the plains than is represented by the ~10% surface exposure. Embayment and lack of correlation of tectonic tessera boundaries with present convection patterns suggest tessera formation largely predates the plains. We are presently assessing two end-member models for the tessera formation: 1) that it represents continuing stages of downwelling following initial stages like the current Lavinia and Atalanta lowlands (3), and 2) that it represents the results of near-global catastrophic downwelling linked to processes such as depleted mantle layer instabilities (7) or catastrophic plate tectonics (8).



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